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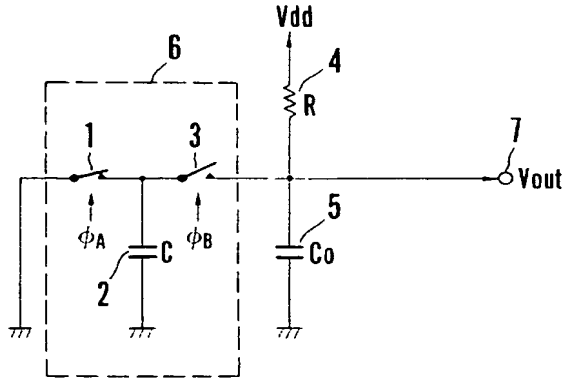
(54) Time constant detecting circuit and time constant adjusting circuit.

(57) The present invention is to provide a time constant detecting circuit incorporated in an LSI, for detection of the variations of component values of resistors and capacitors in the LSI as the variations of a time constant. A pseudo-resistor 6 composed of a switched capacitor circuit. Analog switches 1 and 3 are exclusively switched on and off alternately in a period of T [sec] to control acapacitor 2 to be charged and discharged. With the operation of the capacitor 2 having a capacitance C, there is formed a pseudo-ressitor 6 of a resistance Rp= T/C, prdetermined DC voltage Vout is divided by a series circuit of the pseudo-resistor 6 and an ordinary resistor 4, and smoothed by a caspacitor 5. Output voltage Vout smoothed and allowed to appear at the output terminal 7 is uniquely defined by a time constant τ =1/RC, so that the variations of the time constant formed with the resistors and capacitors in the LSI can be detected by a measurement of the output voltage Vout.

FIG. 1



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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a time constant detecting circuit and a time constant adjusting circuit. The time constant detecting circuit serves to detect variations of a time constant of a circuit including resistors and capacitors such as, for example a RC active filter incorporated in an LSI circuit, and the time constant adjusting circuit serves to adjust the variations of such a time constant.

2. Description of the Prior Art

A monolithic LSI includes therein a circuit which incorporates resistors and capacitors as constituent elements such as for example a RC active filter. This however causes a problem of errors of element values being very large in their absolute values, as well known in prior practice. More specifically, variations of element values of resistors and capacitors are as very small as 1 % or less in the same chip but are as enormously large as 20% ~ 40%, among different chips.

Contruction of such an active filter using resistors and capacitors therefore causes variations of a cutoff frequency ranging from 40% to 100% if variations of such element values range within +/-30%, and thus the cutoff frequency is severely varied and it is very unlikely to realize filters which require accuracy.

To solve such problem of the prior art, recent practice of the construction of filters incorporated in monolithic LSIs are made in the form of switched-capacitor filter type circuits instead of RC type ones. Such switched capacitor filter type circuits, however, surely require aliasing prevention filters and smoothing filters at a preceding stage and at a following stage because of a sampling type construction, only which filters must be constructed with RC active filters respectively. The afore-mentioned variations of cutoff frequency are thus inevitable and bring about several severe problems in designing circuit.

One feature of an arrangement to be described is the provision of a time constant detecting circuit capable of detection of variations of element values in the form of a time constant of a RC circuit in view of the fact that resistors and capacitors formed in an LSI circuit possessing very small errors in their element values.

Another feature is the provision of a time constant adjusting circuit capable of ensuring fine adjustment of such an element value on the basis of a result of detection by the time constant detecting circuit.

A time constant detecting circuit to be described is incorporated in an LSI circuit as part of an associated circuit and includes a voltage dividing resistor circuit composed of a series circuit of a pseudo-resistor formed with a switched capacitor circuit and of an ordinary resistor for dividing applied predetermined DC voltage; and a smoothing capacitor for smoothing divided voltage from the voltage divider resistor circuit.

A time constant adjusting circuit to be described is incorporated in an LSI circuit as part of an associated circuit which includes the time constant detecting circuit mentioned above, a judgement circuit for judging the range of output voltage of said time constant detecting circuit and outputting a control signal in response to the range so judged, and means disposed in an associated circuit including resistors and capacitors as constituent elements thereof for altering the values of corresponding resistors and capacitors by receiving said control signal.

The time constant detecting circuit and the time constant adjusting circuit mentioned above function as follows:

In the time constant detecting circuit, the switched capacitor circuit, although it may be constituted in various ways, includes a capacitor and a plurality ofanalog switches for charging and discharging The capacitor in a period of T [sec], resistance Rp of the pseudo-resistor being Rp=T/C with the capacitance of the capacitor assumed to be C. P. Predetermined voltage is divided by a series circuit of the pseudo-resistor of Rp and an ordinary resistor and is further smoothed through a smoothing capacitor. The smoothed voltage is uniquely defined by a time constant τ =1/RC.

More specifically, the present circuit can detect the variations of values of elements such as resistors and capacitors formed in an LSI circuit as variations of the time constant τ . These variations are effective as data to estimate the variations of the characteristics of a circuit including resistors and capacitors because the relative error in the same chip is very small.

In the time constant adjusting circuit, the range of the output voltage from said time constant detecting circuit is judged and in response to the judged range values of corresponding resistors and capacitors' in an object circuit are altered and finely adjusted. More specifically, upon incorporation of a desired RC active filter in an LSI circuit, the cutoff frequency of the circuit is automatically made adjustable.

Embodiments of the invention, given by way of example, will now be described with reference to the accompanying drawings in which:

FIG.1 is a circuit diagram of a time constant detecting circuit according to a first embodiment of the present invention;

FIG.2 is opening/closing control signals for opening/closing an analog switch illustrated in FIG. 1;

FIG.3 is a circuit diagram of a time constant detecting circuit according to a second embodiment of the present invention;

FIG.4 is a time constant adjusting circuit according to an embodiment of the present invention;

FIG.5 is a circuit diagram exemplarily illustrating a judgement circuit illustrated in FIG.4; and

FIG.6 is a circuit diagram exemplarily illustrating an active filter having an adjusting function.

Referring to FIG.1,there is illustrated a time constant detecting circuit according to the first embodiment of the present invention. In the first embodiment circuit, a series circuit of an ordinary resistor 4 and a pseudo-resistor 6 constructs a resistance voltage dividing circuit in which the ordinary resistor 4 is disposed on the side of a DC power supply and the pseudo-resistor 6 is disposed on the side of ground, and a smoothing capacitor 5 is provided between a junction (an output terminal 7) between both foregoing resistors 4 and 6 and the ground. For the DC power supply either a power supply for a LSI circuit or other DC power supply may be available.

The pseudo-resistor 6 is constructed with a parallel type switched capacitor circuit in the present embodiment. More specifically, the pseudo-resistor 6 comprises a charging/discharging capacitor 2 connected at its one end to the ground, an analog switch 1 disposed between the other end of the capacitor 2 and the ground, and an analog switch 3 disposed between the other end of the capacitor 2 and the output terminal 7 of the present resistance dividing circuit.

In the switched capacitor circuit, the analog switches 1, 3 are exclusively switched on and off alternately in a period of T [sec] in conformity with opening/closing control signals ϕ_A and ϕ_B illustrated in FIG.2 to control the capacitor 2 being charged and discharged When it is assumed that the capacitance of the capacitor 2 is C and the terminal voltage (divided output voltage of the resistance voltage dividing circuit) of the capacitor 5 is Vout, a current I expressed by an expression:

$$T = C.\ Vout/T[A]$$

equivalently flows owing to the operation of the capacitor 2 from the output terminal 7 through the capacitor 5 to the ground during an interval when the analog switch 3 is closed.

Accordingly, the resistance Rp of the pseudo-resistance 6 is expressed by an expression:

$$Rp = T/C[\Omega]$$

The output voltage Vout appearing at the output terminal 7 after smoothed by the capacitor 5 is hereby expressed by:

$$Vout = Vdd\ .\ (T/C)/\{T/(C + R)\}[V]$$

Herein, Vdd is voltage of the DC power supply and R is a resistance of the ordinary resistor 4. The expression is changed to:

$$Vout = Vdd\ .\ \tau/\{\tau + (1/T)\}[V]$$

using a time constant τ ($\tau = 1/RC$).

In other words, the mean output voltage Vout is uniquely defined by the time constant τ formed with the ordinary resistor 4 and the capacitort 2, and it follows that with a measurement of the voltage Vout the time constants τ can be estimatede and detected.

Referring to FIG.3, there is illustrated a time constant detecting circuit according to the second embodiment of the present invention.

In the second embodiment circuit, locations of the ordinary resistor 4 and the pseudo-resistor 6 are changed each other in which the pseudo-resistor 6 is disposed on the side of the DC power supply and the ordinary resistor 4 is disposed on the side of the ground.

In the second embodiment circuit, a current I expressed by:

$$I = C.\ (Vdd - Vout)/T[A]$$

equivalently flows from the DC power supply (Vdd) to the output terminal 7.

The output voltage Vout is accordingly expressed by:

$$Vout = Vdd\ .\ R/\{(T/C) + R\}[V],$$

which is rewritten as:

$$Vout = Vdd\ .\ (1/T)/\{\tau + (1/T)\}[V]$$

using the time constant τ . It is thus understood that the time constant can be detected as in the case of the first embodiment circuit.

Referring to FIG. 4, there is exemplarily illustrated a time constant adjusting circuit for adjusting such a time constant using the time constant detecting circuit described above.

In FIG.4, designated at 34 is a RC active filter which is incorporated in an LSI for filtrating an input signal through an input terminal 32 with a predetermined cutoff frequency and outputting the same from an output terminal 33. In order to adjust the cutoff frequency of the active filter 34 there are assembled a time constant detecting circuit 8 and a judgement circuit 9 in the LSI. In this case, the active filter 34 is constructed with some additional functions.

The judgement circuit 9 receives a detected voltage (foregoing output voltage Vout) appearing at the output terminal 7 of the time constant detecting circuit 8 to judge how the time constant τ is varied and send a plurality of control signals 10 indicative of a judgement result to control input terminals (ϕ_1 through ϕ_n) of the active filter 34. The judgement circuit 9 may be constructed with an A/D converter or may be constructed simply with a combination of a plurality of voltage comparators and a logic circuit.

Referring to FIG 5, there is exemplarily Ilustrated the judgement circuit 9 constructed with the just-mentioned combinatorial circuit.

In FIG 5, designated at 35 through 38 are comparators which have reference values defined by voltage dividing resistors 40 through 44, 39 is a combinatorial logic circuit for processing outputs from the comparators 35 through 38 which comprises AND circuits and NOR circuits.

An output from the time constant detecting circuit 8 (illustrated in FIG.1 or FIG. 3) taken out at the output terminal 7 is compared by the comparators 35 through 38 with the respective reference voltages

generated by dividing the power supply voltage Vdd with the voltage dividing resistors 40 through 44. Outputs from the comparators 35 through 38 are processed with a predetermined logic by the combinatorial circuit 39 and outputted as control signals ϕ_1, ϕ_2, ..., ϕ_n.

Returning here to FIG. 4, the active filter 34 alters element values of the associated resistors and capacitors in response to the control signal 10. Hereby, the active filter 34 is automatically adjusted such that it approaches a predetermined cutoff frequency to the utmost. This is the additional function of the active filter 34 added thereto. A concrete example thereof will be described with reference to FIG. 6.

FIG. 6 exemplarily illustrates the arrangement of a secondary RC active low-pass filter for finely adjusting the cutoff frequency.

In FIG. 6, designated at 31 is an operational amplifier as a main component, on the input side of which there are disposed resistors 13, 16 and capacitors 19, 22 required essentially, and further resistors 11, 12, 14, 15 with which short-circuitting switches 23, 24, 27, 28 are disposed in parallel respectively and capacitors 17, 18, 19, 20, 30, which switches are opened and closed by the four control signals ϕ_1 through ϕ_4 10.

In the illustrated example, the switches 25, 29 are opened and closed by ϕ_1 of the control signals 10 to connect and disconnect the capacitors 17, 20, the switches 26, 30 are opened and closed by ϕ_2 to connect and disconnect the capacitors 18, 21, the switches 23, 27 are opened and closed to short-circuit and connect the resistors 11,14, and the switches 24, 28 are opened and closed by ϕ_4 to short-circuit and connect the resistors 12, 15.

In accordance with the time constant detecting circuit of the present invention, as described above, predetermined DC voltage is divided by the series circuit of the pseudo-resistor constructed with the switched capacitor circuit and of the ordinary resistor, and mean voltage of the divided voltages is outputted.

Accordingly, the output voltage can uniquely be determined by a time constant defined by the capacitor in the switched capacitor circuit and the ordinary resistor to enable the variations of element values of resistors and capacitors formed in an LSI circuit to be detected as the variations of the time constant.

In the time constant adjusting circuit which has been described, the variations of a time constant of a circuit including resistors and capacitors as constituent elements can automatically be finely adjusted to enable a filter with less variations of its cutoff frequency to be formed in an LSI.

In will be understood that, although the present invention has been described, by way of example, with reference to particular embodiments, variations and modifications thereof, as well as other embodiments, may be made within the scope of the protection sought, as defined in the appended claims.

Claims

1. A time constant detecting circuit incorporated in an LSI circuit as part of an associated circuit comprising:

   a resistance dividing circuit composed of a series circuit of a pseudo-resistor formed with a switched capacitor circuit and an ordinary resistor for dividing applied predetermined DC voltage; and

   a smoothing capacitor for smoothing divided voltage by said resistance divider circuit.

2. A time constant detecting circuit according to claim 1 wherein said pseudo-resistor comprises a capacitor connected to ground at its one end, and two analog switches connected with the other end of said capacitor, a terminal of the one analog switch located on the opposite side of the capacitor is grounded and a terminal of the other analog switch located on the opposite side to the capacitor is connected with a junction between said ordinary resistor and said capacitor, said two analog switches being exclusively alternately switched on and off.

3. A time constant adjusting circuit incorporated in an LSI circuit as part of an associated circuit comprising:

   a time constant detecting circuit according to claim 1;

   a judgement circuit for judging the range of an output voltage from said time constant detecting circuit and outputting a control signal in response to said range so judged; and

   means provided in a circuit including resistors and capacitors as constituent elements for receiving said control signal to alter the element values of the corresponding resistors and capacitors.

4. A time constant adjusting circuit according to claim 3 wherein said judgement circuit comprises a plurality of comparators each having different reference values and a combinatorial logic circuit for processing outputs from said comparators in conformity with a predetermined logic.

FIG. 1

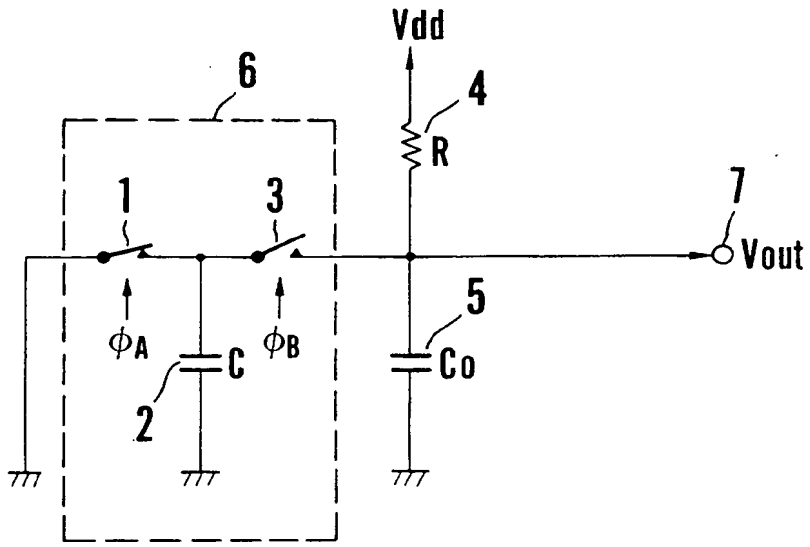

FIG. 2

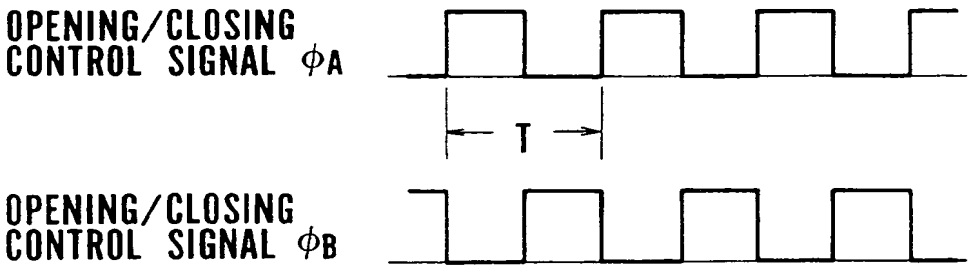

FIG. 3

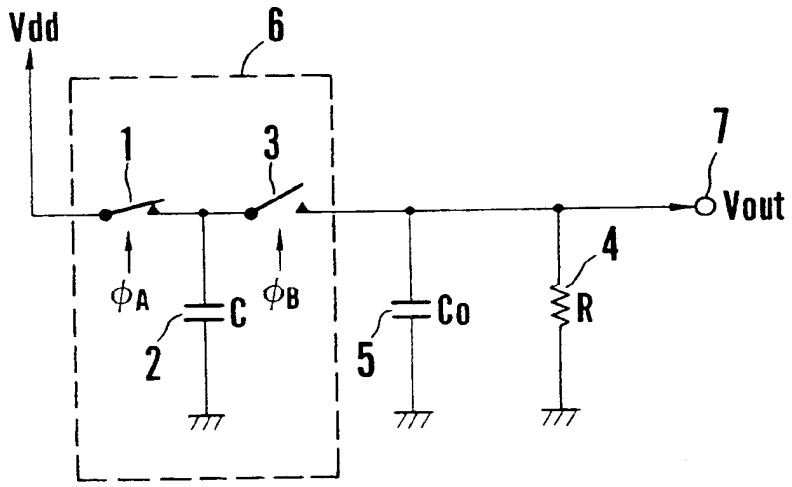

FIG. 4

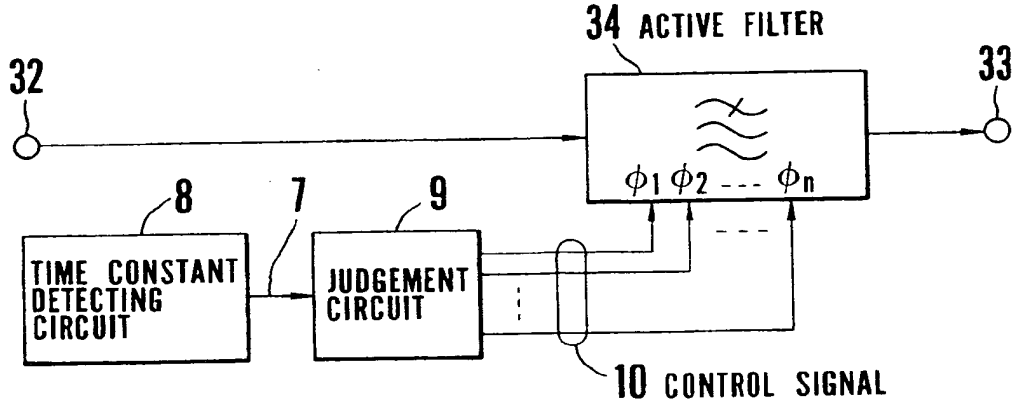

FIG. 5

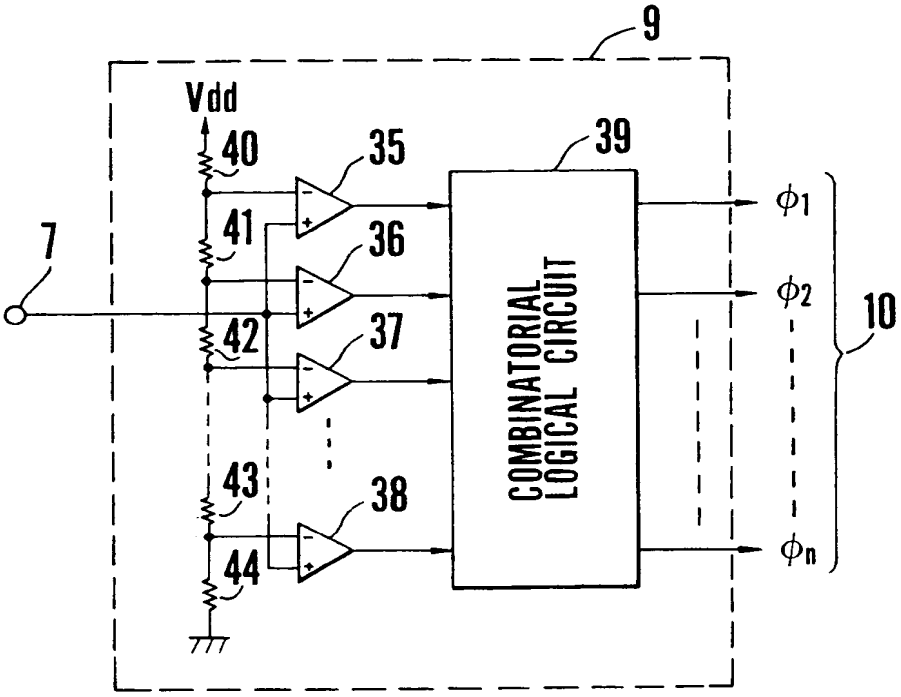

FIG. 6

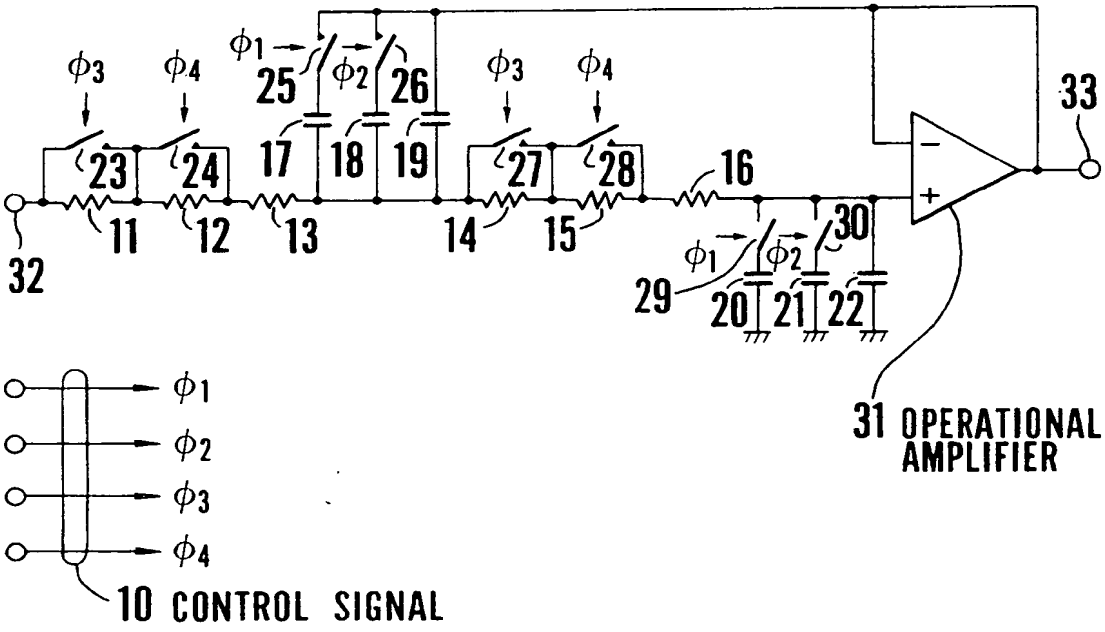

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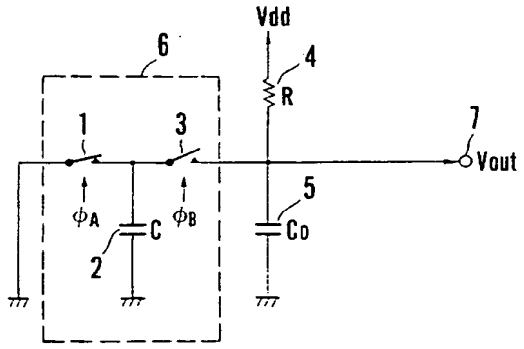
FIG. 1



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EUROPEAN SEARCH REPORT

Application Number
EP 92 31 1784

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	E.D.N. ELECTRICAL SIGN NEWS vol. 30, no. 13, June 1985, BOSTON,USA page 200 BROWN 'circuit measures capacitor's resistance' ---		G01R29/027 G01R27/02
A	MESSEN + PRUEFEN no. 9, September 1982, BAD WOERISHOFEN,DE pages 562 - 566 LAMBECK 'Pruefung komplexer Widestaende mit einem Multivibrator' -----		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	28 SEPTEMBER 1993	HOORNAERT W.

CATEGORY OF CITED DOCUMENTS

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